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Bescheinigung Certificate Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

99202447.1

PRIORITY DOCUMENT

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Der Präsident des Europäischen Patentamts:
Im Auftrag

For the President of the European Patent Office

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I.L.C. HATTEN-HECKMAN

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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

Anmeldung Nr.:
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Anmelder:
Applicant(s):
Demandeur(s):
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Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:
Device for use as stand-alone device and as slave device in a data bus system

In Anspruch genommene Prioriät(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

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Remarques:

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Device for use as stand-alone device and as slave device in a data bus system.

The invention relates to device for use in data bus system such as a USB bus system.

The relevant parts of such a USB system are known from PCT patent application WO99/08422 (assigned to the same applicant as the present application; applicant's ref. No. PHN 16496). A USB bus system comprises a host station connected to a device via a USB cable. The connection may be indirect, via hub station connected to the USB cable, or direct, with the host station itself connected to the USB cable.

The USB cable contains a first and a second power supply conductor and a first and a second data transfer conductors. The power supply conductors serve to supply power from the host station to the device (or from any intermediary station if the device is connected indirectly). USB devices such as a mouse or a keyboard power their operation with the power received from the USB cable. Other devices may have their own power supply and don't use the power from the USB cable.

The data transfer conductors serve for communication of data between the host and the device. The data includes commands send from the host to the device to control the device and data such as mouse position updates or keystrokes. The USB bus system is hierarchical in the sense that all message communication via the data transfer conductors is controlled by the host and the device operates as a slave, which waits for instructions received from the host.

The data transfer conductors also serve to signal attachment of the device to the USDB cable. Any device may be attached to the USB cable at any time, also after the host station has started up. The bus system pulls the potential of the data transfer conductors toward that of the first power supply conductor. The device contains a resistor connected between one of the data transfer conductors and the second power supply conductor, so that the potential of the data transfer conductor is pulled toward that of the second power supply conductor when the device is attached to the USB cable. The host station monitors the potential of the data transfer conductor (directly or by means of a hub station). If the potential of the data transfer conductor shifts towards that of the second power supply conductor, a "connect condition" is said to occur, signaling to the host station that a device has been attached. Once the host

station detects the "connect condition", the host station starts communicating with the device, in order to set-up the device and to set the device into action.

The device according to WO99/08422 has a switch in series with the second resistor. When the device is switched on the switch is initially non-conductive and it is made conductive only after the device has had time to initialize itself. Thus the device creates a delay between attachment and the occurrence of the "connect condition". The delay gives the device the opportunity to initialize itself before the host can communicate with the device to set it in action. When there is no host station, or the when the host station is switched-off, the device does not get into action.

Earlier filed patent application No. EP 99201337.5 (unpublished at the time of filing the present application; assigned to the same applicant as the present patent application), which is incorporated herein by way of reference, describes how a device can be used either as a hub connecting the host station to the subsystem or as a host of the subsystem. However, this earlier filed patent application does not describe the use of the power supply to detect the absence of presence of an active host station.

It is an object of the invention is to provide a way to make it possible to use the device also when it is not connected to an active host station via the cable.

The device according to the invention is described in Claim 1. Preferably, the device is for use in a USB bus system. According to the invention, the device uses the presence or absence of power supply on the bus cable to decide whether to start operating in a stand-alone mode or to wait for data transfer from the host station to operate as a slave. If no power is supplied via the bus cable, the device operates in the stand-alone mode.

By "stand-alone" it is meant that the device does not operate in the bus system as "slave" of the host station. In the stand-alone mode the device operates independent from any messages from the data transfer conductors. The device starts actions that the device would not take, or would only take upon command by the host station, if the host station had been detected. "Stand-alone" does not exclude the possibility that the device itself acts as host station for a bus-subsystem connected to the device. Claim 2 describes an embodiment of the device according to the invention. In this embodiment, the device disables the creation of a "connect condition" (pulling the potential of the data transfer conductor back to the potential

of one of the power supply conductors) when in the stand-alone mode. This prevents that a host station will unexpectedly try to start communication with the device when the device is attached to the bus system during operation in the stand-alone mode. In the slave mode, creation of the "connect condition" is normally enabled.

Claim 3 describes an embodiment of the device according to the invention that uses a single connection of the control circuit both to sense whether a host station is present and to control the generation of the "connect condition". The data transfer conductor is connected via a resistive element to a potential source to pull the potential of the data transfer conductor so as to create the connect condition. Preferably, the potential source is derived from the power supply conductors.

Another embodiment of the device according to the invention is described in Claim 5. This embodiment allows the device to continue testing whether the device is attached to an active bus system, also after the device has initially entered the stand-alone mode or the slave mode. Thus, the device can switch from the stand-alone mode to the slave mode or vice versa, dependent on whether or not a power supply is detected on the power supply lines during operation in the stand-alone mode or the slave mode. The device may provide for switching from the stand-alone mode to the slave mode, or for switching from the slave mode to the stand-alone mode or both.

When switching from the slave mode to the stand-alone mode or vice versa, a resistive connection between the data transfer conductor and the first one of the power supply conductors is preferably switched off an on respectively, to simulate disconnect and connect of the device. In a further embodiment, the device uses a single connection to its control circuit both to monitor the power supply and to control signaling of the connect condition.

These and other advantageous aspects of the device according to the invention will be described in more detail using the following figures.

Figure 1 shows a bus system

Figure 2 shows an embodiment of a connect circuit

Figure 1 shows a bus system. The bus system comprises a host station part 10 and a device 14 connected via a cable 12. The host station part may be for example a USB host station, or part of a USB system containing a host station connected to one or more hubs,

the cable 12 being coupled to a port of a hub. The cable 12 comprises power supply conductors 120, 122 and data transfer conductors 124, 126. The device 14 has a connector 16 connecting the device 14 to the cable 12. The device 14 contains a data reception circuit 140 coupled to the data transfer conductors 124, 126 for receiving and transmitting messages via the data transfer conductors 124, 126.

The device 14 also contains a control circuit 142 (implemented for example as a suitably programmed micro-controller), a connect circuit 144 and resistors 146, 148. The control circuit 142 has an input/output connection coupled to a control input of the connect circuit 144 via a node 149. The node 149 is coupled to the power supply connections 120, 122 of the cable 12 via resistors 146, 148 respectively. The device 14 is powered by its own power supply (not shown).

In operation, the host station part 10 initially supplies a power supply voltage (e.g. 5V) across power supply conductors 120, 122. This power supply voltage may be used to power simple devices 14 that have no own power supply, such as a mouse or keyboard attached to the system. The data transfer conductors 124, 126 are connected the low voltage power supply conductor 122 via respective resistances (not shown). Thus, absent any other connections to the data transfer conductors 124, 126, the potential of these data transfer conductors 124, 126 would equal that of power supply conductor 122.

This is an initial situation, which occurs before the device 14 is switched on before the device has been attached to the host station part 10 via the cable 12. According to the USB specification, the device 14 contains a resistor (not shown in figure 1) connected to one of the data transfer conductors 124, 126 to pull up the potential of that data transfer conductor 124, 126 towards the potential of the high power supply conductor 120. Because the potential of these data transfer conductors 124, 126 is pulled resistively, it is still possible to impose data transfer signals on these conductors, by using a strong enough driver circuit. The pull-up enables the host station part 10 to detect that the device 14 has been connected to the bus system. In response, the host station part 12 will start communicating with the device via the data transfer conductors 124, 126, in order to configure the device 14. Afterwards, the host station will write or read data to and from the device and send control signals as appropriate for using the device.

Typical examples of USB devices are a mouse, a keyboard, a computer display a camera etc. If the device 14 is not attached to the host station part 10, or when the host station part 10 is not switched-on a USB device would conventionally remain inactive, waiting

until the host station part 10 is attached or switched on and starts sending messages over the data transfer conductors.

The device 14 according to the invention detects whether an active host station part 10 is attached to the connector 16 and switches to a stand-alone operating mode if this is not the case. The device 14 tests the power supply voltage supplied via the power supply conductors 120, 122 to detect whether an active host station part 10 is attached. If this power supply voltage is zero or less than a predetermined threshold, the device 14 start operating in a stand-alone mode. For example, the device may be able to operate using local information or information obtained via the internet, the device being connected to the internet via the host station part 10. When no active host station part 10 is attached, the device 14 starts operating "stand-alone" using local information. Otherwise, the device operates as a slave, receiving information (e.g. access keys) from the internet via the host station part. Of course many other applications of stand-alone vs. Slave operation are possible, such consumer audio and video equipment (video recorder, CD player, TV, audio set etc.) that is either controlled by a host as part of a system or operates stand-alone.

To select between stand-alone operation and slave operation, the control circuit 142 has a connection coupled to the power supply conductors 120, 122. The control circuit 142 switches this connection as an input, to sense whether an active host station part 16 is connected to the device 14. If an active station part 10 is connected, the resistors 146, 148 form a voltage divider. (Resistor 146 being smaller than resistor 148, so that the potential of the node 149 is closer to that of the high power supply conductor 120 than to that of the low power supply conductor 122). This results in a high voltage at the node 149, which is detected by the control circuit 142, which consequently starts sets the device to operate as a slave. If the device is disconnected from the cable 12, the connection for the high power supply conductor floats and the potential of the node 149 is pulled to the potential of the low power supply connected to the control circuit 142. As a result, the control circuit set the device 14 to operate in the stand-alone mode. Similarly, if no power supply voltage is present across the power supply conductors 120, 122 the voltage at the node 149 will be low and the device will operate in the stand-alone mode.

Preferably, this test for the presence of an active host station part 10 is repeated periodically, so that the device 14 can switch between the stand-alone mode and the slave mode, dependent on the appearance or disappearance of the power supply voltage.

When the device 14 operates in the slave mode, this mode should be made detectable for the host station part 10, by connecting a pull-up circuit to one of the data

transfer conductors 124, 146. Preferably, this pull-up circuit is disabled when the device 14 is not prepared to operate in the slave mode, for example, when the device 14 is initializing itself, when it operates in the stand-alone mode, or when the control circuit has not yet decided whether to operate in the stand-alone mode or in the slave mode.

For this purpose a connect circuit 144 is provided. Under control of the control circuit 142, the connect circuit 144 either pulls up the potential of one of the data conductors 124, 126 or passively or actively allows this potential to be pulled down. As shown in figure 1, a single node 149 connected to the control circuit 142 is used to control the connect circuit. This is a preferred embodiment, because it economizes the use of output pins of the control circuit 142. However, one may of course use separate inputs and outputs (not shown) of the control circuit 142, to sense the voltage on the power supply connections 120, 122 and to control the connect circuit 144 respectively.

For use with a single node 149, the connect circuit 144 is arranged to disable the pull-up of the data transfer conductor 124, 126 when the potential of the node 149 is high due to the presence of a sufficient power supply voltage on the power supply conductors 120, 122. When the device 14 is prepared to operate in the slave mode, the control circuit 142 switches its connection to the node to be an output pin that drives a low voltage to the node 149. When the voltage of the node is low, the connect circuit 144 enables pull up of the data transfer conductor 124, 126. Preferably, the connect circuit is designed to provide a delayed response to rising of the potential of the node 149. Thus, the pull-up will remain active for a short time interval (of say 1 msec) if the control circuit 142 temporarily switches its connection to the node to (high impedance) input, in order to sense whether a power supply voltage is still present on the power supply conductors. This enables the periodic tests of the power supply, without disconnecting the device 14 form the system.

Figure 2 shows an embodiment of the connect circuit 144. The connect circuit 144 comprises a PMOS transistor 20, a resistor 22 and a capacitor 24. A main current channel of the PMOS transistor 20 is switched in series with the resistor 22 between a connection D for one of the data transfer conductor 124, 126 (not shown) and a connection VBUS for the high power supply conductor 120 (not shown). The capacitor 24 is switched in parallel with the main current channel of the PMOS transistor 20. Also shown in figure 2 are the resistors 146, 148, the node 149 and a connection GND for the low power supply conductor 122 (not shown) from figure 1.

In operation the resistor 22 serves to pull up the potential of the data transfer conductor 124, 126 when PMOS transistor 20 is conductive. The voltage of the node 149

controls whether the PMOS transistor 20 is conductive. Resistors 146 and 149 are chosen so that the gate source voltage of PMOS transistor 20 will be below its threshold voltage when the connection of the control circuit 142 to the node 149 is switched as input. In this case, the data transfer conductor 124, 126 will not be pulled up by resistor 20, so that the host station part 10 will observe the cable as not connected.

When the control circuit 142 switches its connection to the node to output and pulls the voltage of the node 149 down, PMOS transistor 20 will become conductive. As a result resistor 22 will pull up the potential of the data transfer conductor 124, 126, indicating to the host station part 10 that the device is connected (and prepared to act as slave).

When the control circuit 142 briefly switches its connection to node 149 back to input, in order to sense whether power is still supplied via the power supply conductors 120, 122 of the cable, capacitor 24 will temporarily allow resistor 20 to continue to pull up the potential of the data transfer conductor. The capacitance of the capacitor 24 has been selected so that it will not discharge significantly during the time needed by the control circuit 142 to test the potential of the node 149. Thus, the control circuit can test the power supply while in the slave state without interrupting the connection to the system.

Of course, the connect circuit is only one possible embodiment to perform this function. For example, one might connect a resistor between VBUS and D and use an NMOS transistor to pull down the potential of D to signal that the device is not connected. In this case a buffer circuit (e.g. a resetable delay circuit) may be included between the node 149 and the gate of the NMOS transistor to keep the NMOS transistor non-conductive when the potential of the node 149 temporarily becomes high during testing for the presence of the power supply. A similar buffer may be used in between node 149 and the gate of PMOS transistor 20 instead of capacitor 24 to keep that transistor 20 temporarily conductive during sensing of the node 149. Also the resistor 22 may be connected to the own power supply of the device 14 (via PMOS transistor 20 in case of figure 2) instead of to the power supply VBUS received from the cable 12. However, connection to the power supply from the cable is preferred in the case of figure 2, because this makes it easier to ensure that PMOS transistor 20 operates properly.

CLAIMS:

1. A device for use in a data bus system, wherein the bus system comprises a host station, a bus cable and the device coupled to the host station via the bus cable, the bus cable comprising a data transfer conductor and power supply conductors for enabling the device to obtain operating power from the bus system via the bus cable, the device comprising a connector for coupling the device to the bus cable, and a control circuit coupled to the connector, characterized in that the control circuit is arranged to detect whether a power supply is connected to the power supply conductors and to start waiting in a slave mode for commands received via the data transfer conductor or to start operating in a stand-alone mode, dependent on whether or not connection of the power supply has been detected respectively.

2. A device according to Claim 1, wherein the bus system comprises a pull circuit for pulling a potential of the data transfer conductor away from a potential of a first one of the power supply conductors, the bus system being arranged to detect whether or not the potential of the data transfer conductor is pulled back to the potential of the first one of the power supply conductors via the bus cable, so as to determine whether the device is connected to the bus cable, wherein the device comprises a pull back circuit for pulling back the potential of the data transfer conductor to the potential of the first one of the power supply conductors, the control circuit enabling and disabling the pull back circuit when operating in the slave mode and the stand-alone mode respectively.

3. A device according to Claim 1, wherein the bus system comprises a pull circuit for pulling a potential of the data transfer conductor away from a potential of a first one of the power supply conductors, the bus system being arranged to detect whether or not the potential of the data transfer conductor is pulled back to the potential of the first one of the power supply conductors via the bus cable so as to determine whether the device is connected to the bus cable, the device comprising a first resistive element and a switching element, connected in series between the data transfer conductor and a pull back potential source, the device comprising a node coupled to a control electrode of the switching element, a second and third resistive element coupled between the node and the first one and a second one of the power

supply conductors respectively, so that the switching element is non-conductive when a potential of the node is affected only by the power supplied via the power supply conductors via the second and third resistive element, the control circuit having an I/O connection coupled to the node, the control circuit switching the I/O connection as an input to detect whether power is supplied via the power supply conductors and the control switching the I/O connection as an output to make the switching element conductive to enable pull back.

4. A device according to Claim 3, wherein the pull back potential source is the first one of the power supply conductors.

5. A device according to Claim 1, wherein the control circuit is arranged to detect repeatedly whether power is supplied via the power supply conductors when the device operates in the slave mode or the stand-alone mode, the control circuit switching from the slave mode to the stand-alone mode and/or vice versa when absence or presence of power supply is detected respectively.

6. A device according to Claim 5, wherein the bus system comprises a pull circuit for pulling a potential of the data transfer conductor away from a potential of a first one of the power supply conductors, the bus system being arranged to detect whether or not the potential of the data transfer conductor is pulled back to the potential of the first one of the power supply conductors via the bus cable so as to determine whether the device is connected to the bus cable, wherein the device comprises a pull back circuit for pulling back the potential of the data transfer conductor to the potential of the first one of the power supply conductors, the control circuit enabling and/or disabling the pull back circuit when switching from the stand-alone mode the slave mode or vice versa respectively.

7. A device according to Claim 6, wherein the pull back circuit comprises a first resistive element and a switching element, connected in series between the data transfer conductor and a pull back potential source, a delay element for holding a voltage across the switching element for a limited time interval after the switching element is signaled to switch from conductive to non-conductive, the device comprising a node coupled to a control electrode of the switching element, a second and third resistive element coupled between the node and the first one and a second one of the power supply conductors respectively, so that the switching element is non-conductive when power is supplied via the power supply

conductors and a potential of the node is affected only via the second and third resistive element, the control circuit having an I/O connection coupled to the node, the control circuit switching the I/O connection as an input to detect whether power is supplied via the power supply conductors and the control switching the I/O connection as an output to make the switching element conductive when the device waits in the slave mode.

8. A device according to Claim 1, wherein the bus system is a USB bus system.

ABSTRACT:

A device is provided for use in a data bus system like a USB bus system. The device can be coupled to a host via a bus cable that comprises a data transfer conductor and power supply conductors. The device detects whether a power supply is connected to the power supply conductors. Dependent on whether or not connection of the power supply has been detected, the device starts operating in a slave mode or in a stand-alone mode respectively. In a slave mode the device waits for commands received via the data transfer conductor. In the stand-alone mode the device operates independent from communication via the cable. Preferably, the device signals back to the host whether it is in the slave mode by enabling pull-up of a potential of the data transfer conductor. In an embodiment, detection and signaling is controlled via a single control node.

Fig. 1

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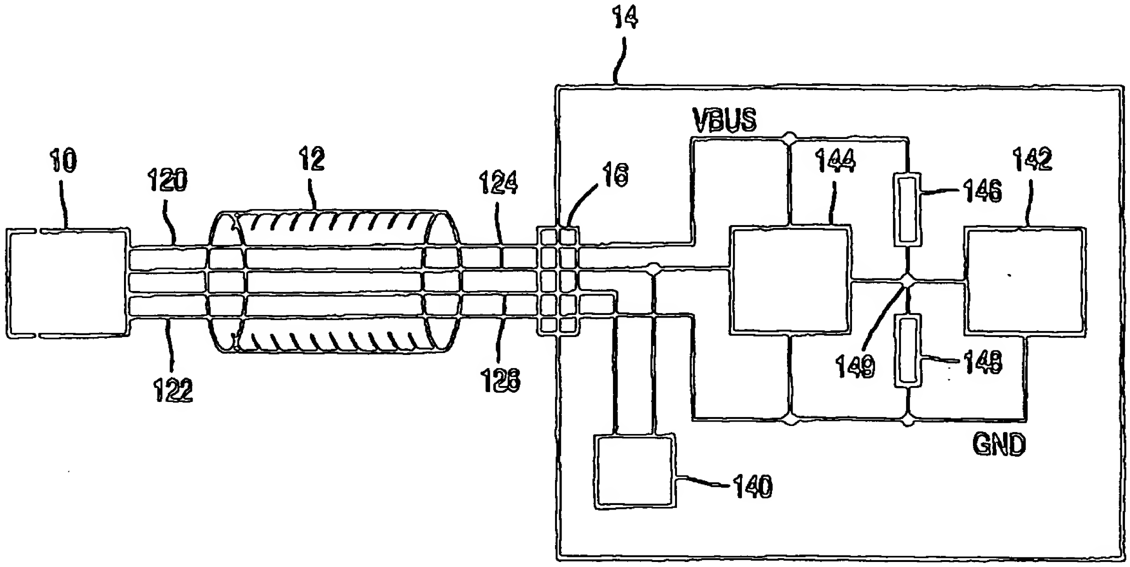

FIG. 1

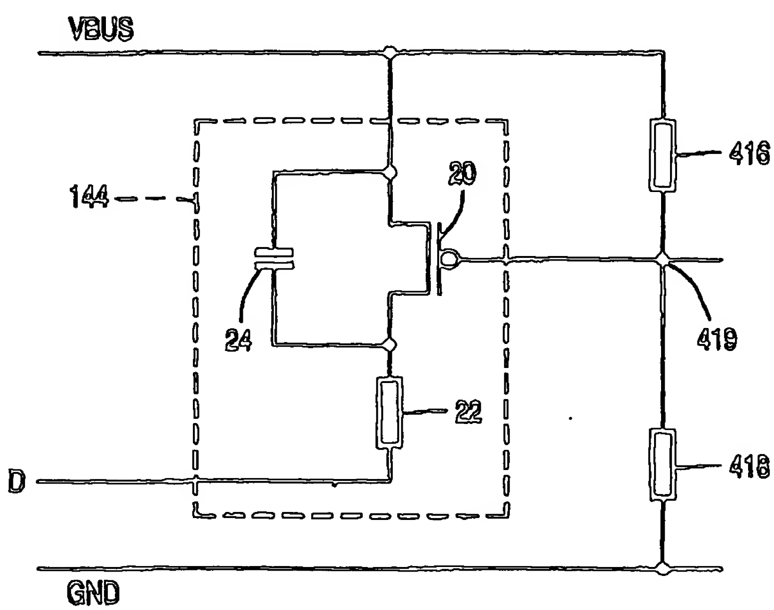

FIG. 2

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Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

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99201337.5

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For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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Anmelder:
Applicant(s):
Demandeur(s):
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5621 BA Eindhoven
NETHERLANDS

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:
Communication bus system and apparatus for use in a communication bus system

In Anspruch genommene Prioriät(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

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Pays:

Tag:
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Aktenzeichen:
File no.
Numéro de dépôt:

Internationale Patentklassifikation:
International Patent classification:
Classification internationale des brevets:
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Remarks:
Remarques:

Communication bus system and apparatus for use in a communication bus system.

The invention relates to an apparatus for use in a communication bus system and to a communication bus system. An example of a communication bus system is a USB (Universal Serial Bus) system, discussed for example in US patent No. 5,784,581. The USB system provides for communication between a number of slave stations and a host station. The host and slave stations are connected to each other in a tree topology. The host is connected to a number of slave stations and/or a number of hub stations. The hub stations in turn may be connected to further slave stations or further hub stations and so on. Thus, each slave station is connected to the host station either directly or via a number of hub stations.

The host station has a number of slave connectors for connecting slave stations or hub stations. The slave stations each have a host connector for connection to the host station, either directly to a slave connector of the host station or indirectly via one or more hub stations. Each hub station has a host connector and one or more slave connectors. The host connector is for connecting the hub station to a slave connector of the host station either directly or via other hub stations. The slave connectors are for connection to the host connectors of slave stations or other hub stations.

The USB system allows for incorporation of new stations into the system when the system is already running normally (i.e. when it is no longer in an initialization phase). This occurs for example when a user physically connects the host port of a slave station or hub station on one hand to a slave port of a host station or hub station on the other hand. Incorporation also occurs when the user switches on the power to a slave station or hub station later than to other stations. Collectively this will be referred to as "introduction" of a station into the system.

Upon introduction, the station to whose slave port the new station is connected will detect the presence of the new station. This is reported to the host station, which will then incorporate the station into the system, for example by assigning it a unique identifier, entering it in tables etc. If the new station is a hub station, the host station will cause this hub station to sense signals on its slave connectors to determine whether any active stations are connected to the slave ports. If so, this is signaled to the host processor, which then also incorporates these stations into the system.

The host station controls all communication in the USB system. If the host station is switched off, or even completely absent, no communication is possible in the USB system. This has the disadvantage that slave stations cannot use the USB system in the absence of the host station.

US patent No 5,784,581 teaches an apparatus that overcomes this problem. This apparatus is capable of operating both as a host station and as a slave station. The apparatus has both a slave connector and a host connector. As long as the apparatus is not introduced as a slave station into a USB system with its host connector, the apparatus operates as host station to a slave station or stations that are connected to the slave connector. Once the apparatus is incorporated into a USB system as a slave station, it stops operating as a host station. An example of such an apparatus is a video recorder that can communicate as a host station with a camera to record data from the camera under its own control, or function as a slave that records if instructed to do so by a host station. In the latter case, data from the camera passes to the host station from the camera and from the host station to the recorder. In this case the slave port of the apparatus is disabled.

When the apparatus according to US 5,784,581 is connected to the host station, it stops functioning as a host immediately, so that it does not create interference in the communication between its former slaves and the new host station. The slave stations have to be able to report to the new host station within a relatively short time required by the USB protocol. This means that the operation of the apparatus will be interrupted abruptly upon introduction to the USB system of the new host.

Amongst others, it is an object of the invention to provide for a bus communication system that can operate both before and after connection of a new host station without abrupt interruption of communication upon connection of the new host station.

It is a further object of the invention to provide for an apparatus that can operate both as a host station and a slave station and that can switch between operation as a host station to its own slave station and as a slave station in its own time.

The apparatus according to the invention is described in Claim 1. The apparatus according to the invention allows the apparatus to be part of more than one independent USB-like communication bus system at the same time. When the apparatus is part of a USB-like

communication bus system with a first host station, the apparatus may be introduced into an another USB-like bus communication bus system with another host station. The apparatus has the freedom to decide for at least one of its slave connectors to which host station it assigns that slave connector when the apparatus is introduced into the other USB-like communication bus system. When the slave connector is assigned to one communication bus system, the apparatus supplies the signals (including lack of signals) to the host of the other communication bus system that the apparatus normally generates in response to the absence of a connection to the slave connector.

Preferably the slave connector may be transferred from one communication bus system to a new communication bus system during continued operation of both communication bus systems. The apparatus reports this to the new communication bus system with the signals that the apparatus normally generates in response to connection of a new slave station to the slave connector.

Preferably, the apparatus contains its own host processor that can act as a host station to the slave stations connected directly or indirectly to the slave connector when no other host station is connected to the host connector of the apparatus.

There is a risk that a user will connect a slave connector of the apparatus to its host connector. This may degrade the communication bus system if the apparatus responds as if a different host station has been connected. For example, the apparatus may start waiting for initiatives from the new host that are not forthcoming, because the apparatus itself is the new host. Also signals from the apparatus may cause pseudo conflicts if the apparatus receives back these signals as if they come from a different host station. In the USB protocol the host station assigns an identification code to newly introduced slave stations using the USB enumeration process. When a slave connector is connected to the host connector, the apparatus will transmit a signal to assign an identification code to the slave connector and receive it back on its own host connector.

In principle, each time the apparatus receives a signal to set an identification code after transmitting this kind of signal itself, this may be due to a connection between a slave connector and the host connector. Preferably, the apparatus compares the identification code that it transmits as a host station with identification codes included in signals received simultaneously with the transmission or shortly after the transmission (within the maximum allowable transmission delay of the communication bus system). If the identification codes are equal, it is likely that the slave connector has been connected to the host connector and in response the apparatus preferably disregards the connection to the slave connector. Of course

there is a small possibility that the identification code received at the host connector originated from a different host station even in this case. To reduce the probability that this leads to problems, the apparatus preferably responds to equal identification codes by transmitting a signal assigning another identification code. The slave port is then disregard only if this identification code is also received back.

These and another advantageous aspects of the invention will be described and illustrated with examples using the following figures.

Figure 1 shows a bus communication system

Figure 2 shows an apparatus for use in a communication bus system

Figure 3 shows a bus communication system divided into two sub systems

Figure 4 shows a bus communication system divided into two different sub systems.

Figure 1 shows a typical bus communication system with tree structured connections, such as a USB (Universal Serial Bus) system, which is commonly used to connect PC's (personal computers) to peripheral devices.

The USB bus allows a non-expert user to connect apparatuses in a tree structure of connections. The apparatuses can communicate via the tree structure. An apparatus can be connected no matter whether other apparatuses are already actively connected to the tree structure or not. Similarly, the apparatus can be on or off when it is connected.

At the root of the tree structure is a host station 10 which has one or more USB connectors 10a,b. At the leaves of the tree are slave stations 11, 13, 15, 16. To each of the USB connectors 10a,b of the host station 10 the user can connect either a slave station 11 or a hub station 12. The hub stations 12 in turn also have such USB connectors 12a,b to which slave stations 13, or other hub stations 14 can be connected and so on.

The host station 10 controls communication through the USB bus system. The host station 10 addresses slave stations 11, 13, 15, 16 via the USB connectors 10a,b and via hub stations 12, 14 if necessary. Data is passed between the host station 10 and the addressed slave stations 11, 13, 15, 16, if necessary via the hub stations.

A new station such as a hub station 12, 14 or slave station 11, 13, 15, 16 can be connected to the bus system while the bus system is running. Also, stations 11-16 that are

already connected but not yet switched on may be switched on. Collectively, connection of a switched-on station and switch on of a connected station will be referred to as "introducing the station into the system" or more briefly "connection". The process of making the new station accessible in the system that starts with this "connection" will be termed "incorporation into the system".

The host station 10 or hub station 12, 14 to which the new station is connected senses the interaction of the new station. In a USB system this is realized because the new station pulls up a potential on a pin of the USB connector. In response to the introduction, the host station records the presence of the new station and opens a communication channel to read out the type of the new station. If desired, the host station 10 then starts other communication with the new station.

In case the new station is a hub station 12, 14, the host station 10 subsequently causes the new station to activate its USB connectors. As a result, it is possible to detect further stations (hub stations or slave stations) that are connected to these USB connectors. The presence of such a further station is reported back to the host station 10, which then opens up a communication channel to the further station and so on.

Figure 2 shows an apparatus 20 according to the invention, for use in a communication bus system, such as a USB (Universal Serial Bus) system. The apparatus 20 contains a hub circuit 22, a local host processor 24, a host connector 26 and slave connectors 22a-c. The hub circuit 22 is connected to the connectors 26, 28a-c and the local host processor 24.

The apparatus 20 is designed to be able to operate with and without a host station connected to the host connector 26. In case a host station connected to the host connector 26, the apparatus can operate as a normal hub station, the hub circuit 22 performing the known functions of the hub station. In case no host station is connected to the host connector 26, the local host processor 24 operates as host processor, communicating with slave stations connected to the slave connectors 28a-c.

When a host station is connected to the host connector 26, the hub circuit 22 is capable of functioning as a pair of hub stations, one hub station connecting the host connector 26 to a number of the slave connectors 28a-c and another hub station connecting the local host processor 24 to different ones of the slave connectors 28a-c. Thus, two mutually isolated USB systems may be formed, both including the apparatus 20.

Figure 3 shows a system divided into two mutually isolated USB systems 30, 32, that both include the apparatus 20. The system contains a number of the slave stations 34a-

d and hub station 36 connected to slave ports of the apparatus assigned to different ones of the USB systems 30, 32.

Figure 4 shows the same system divided in a different way into two mutually isolated USB systems 40, 42, that both include the apparatus 20. The apparatus 20 determines which of the slave stations 34a-d and hub station 36 belong to which system.

The selection which slave connectors 28a-c of the apparatus belong to which of the two isolated USB systems is dynamical: the hub circuit 22 can report the slave connectors 28a-c to the hosts of both US systems, but for each particular slave connector 28a-c the hub circuit 22 signals to at most one of the hosts that an active station is connected to that slave port 28a-c. Selection of the host to which the presence of the active station is signaled determines the USB system to which that station belongs.

It is possible that, during the time when the local host processor 26 operates as host processor, a new host processor is connected to the host connector 16 (either directly or via one or more hub stations). In this case, the hub circuit 22 will signal its presence to the new host station connected to the host connector 26, using the normal USB protocol. In response to that signal the new host will instruct the hub circuit to activate the slave ports 28a-c. In response the hub circuit 22 generates signals back to the new host station via the host port 26. In the normal USB protocol, these signals differentiate between slave ports 28a-c to which an active apparatuses connected and other slave ports 28a-c where this is not the case.

In case of the apparatus of figure 2, the slave ports 28a-c may already be in use by the local host processor 24. If so, the signals back from the hub circuit 22 to the new host station simulate that no connection is present to those slave ports 28a-c that are in use by the local host processor 24. As a result, the new host station will not attempt to establish communication through these slave ports 28a-c and the local host station can continue to communicate via those slave ports 28a-c.

Preferably, the apparatus 20 contains a number of flag storage locations 29 accessible both for the local host processor 24 and the hub circuit 22, to represent whether or not respective ones of the slave connectors are in use by the local host processor 24. The hub circuit 22 reports slave connectors 18a-c to the new host as disconnected if the flags indicate that these slave connectors are in use. The other slave connectors are reported normally, i.e. as connected or disconnected, depending on whether they are physically connected or disconnected respectively.

Preferably, the hub circuit 22 reports to the local host processor 24 that a slave port 28a-c has been disconnected if that slave port is reported normally to the new host. Thus,

the local host processor will no longer attempt to start communication with those slave ports 28a-c. This will happen only to those slave ports 28a-c for which the local host processor 24 has indicated that it can suffer such abrupt disconnection without problems, by means of the flag storage locations 29.

Because the local host processor 24 and the hub circuit 22 are internal to the apparatus 20, both can have access to the flag storage locations 29 outside the normal USB communication channels. As an alternative, the local host processor 24 may be located outside the apparatus and be connected to it via a further host connector (not shown) of the apparatus 20. In this case, the local host processor 24 preferably communicates via the USB protocol which slave connectors it uses and which not, or more precisely from which slave connectors the local host processor can tolerate abrupt disconnection.

For this purpose the hub circuit 22 may provide a virtual slave connector, to which the local host processor can send messages to write into the flag storage locations 29 concerning "in use" status of the other slave connectors.

When the local host processor 24 stops using one or more of the slave ports 28a-c, the hub circuit 22 simulates signals back to the new host station as if a connection to those one or more slave connectors 28a-c has just been established. In this case, the new host station will start communication via those slave connectors just as after a connection has been made.

In one embodiment, connection of the new host station is signaled to the local host processor 24 and the local host processor 24 responds to this information by finishing interactions with slaves via the slave connectors 28a-c. The local host processor 24 preferably does this by completing ongoing data transfers and sending such control commands as are necessary for completing processes running on the local host processor 24 and/or the slaves, rather than abruptly terminating all communication. Such a completion generally takes more time than the maximum response time allowed by the USB protocol for slaves to respond to signals from the new host. This is no problem, because the new host will not be expecting responses from any slaves that are used by the local host processor 24, since the hub circuit 22 has simulated absence of such slaves.

Preferably, the hub circuit 22 signals connection of the new host to the local host processor 24 by signaling to the local host processor 24 that a slave has been connected to a virtual slave connector (i.e. a connector that is not physically present in the apparatus 20 or anywhere else). Preferably, the local host processor 24 contains a software driver program for

receiving signals from the virtual connector, the software driver program triggering completion of communication with the slave connectors 28a-c.

In one embodiment, the software driver program prompts the human user of the application programs running on the local host processor 24 to terminate or reconfigure such applications, so that the slave connectors 28a-c will be freed for the new host.

There is a risk that one of the slave connectors 28a-c will be connected directly or indirectly to the host connector 16. In a normal USB bus system this is not a problem, because the host processor 10 does not have a host port and hub stations, which do have a host port, never take any initiative to start communication.

However, in case the local host processor 24 acts as host processor connected to a part of the USB bus system connected to one of the slave connectors 28a-c, a slave connector in that part of the USB bus system may be connected to the host connector 26. In this case, that connection will be reported back to the local host processor 24, which will respond by establishing connections to the newly connected station, i.e. with the apparatus of which the local host processor 24 is itself a part. This is not an immediate problem, because the hub-circuit will simulate that the slave connectors 28a-c that are used by the local host processor 24 are disconnected. As a result no loop connections will be established.

However, on a longer term the connection to the host connector 26 may cause the local host processor 24 to shut down communication to slave connectors 28a-c. In case of a loop connection from one of the slave connectors 28a-c back to the host connector 26 (directly or indirectly via hub stations), this is undesirable because the shut down is unnecessary, there being no new host that will use the slave connectors 28a-c.

To prevent unnecessary shut down, the hub circuit 22 preferably checks whether a loop connection is established. This can be done using a property of the USB protocol. When a station 11-16 is connected to the USB bus, the host station 10 assigns an identification number to the newly connected station. The local host processor 24 will to this in case of a connection (directly or indirectly) to one of the slave connectors 28a-c.

In case of a loop, this identification number will be received back by the hub circuit 22 via the host connector 26. The hub circuit 22 compares the identification numbers received via the host connector 26 with identification numbers transmitted at the same time (or shortly before) by the local host processor 16 via any one of the slave connectors 28a-c. In case these identification number are equal, a potential loop is signaled. In this case, the local host processor 24 transmits a new identification number to the same station as before. If this new identification number is also received back via the host connector it is concluded that

there is a loop. The hub circuit then simulates disconnection of the host connector 26 and the local host processor 24 does not shut down communication with the slave connectors 28a-c.

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CLAIMS:

1. An apparatus for use as a hub station in a communication bus system that contains a host station connected to a host connector of the apparatus and a slave station connected to a slave connector of the apparatus, the communication bus system operating according to a communication protocol wherein the hub station generates a presence signal on the host connector upon incorporation of the hub station into the system via the host connector, the presence signal being dependent on whether the hub station detects a slave device connected to the slave connector, wherein the apparatus comprises

- an alternative host port;
- a hub circuit operatively connected to the host connector, the slave connector and the alternative host port, the hub circuit being arranged to pass communication between the alternative host processor and the slave device via the alternative host port and said slave connector and to generate the presence signal simulating absence of a connection to the slave connector when the hub station is incorporated into the system at a time when the alternative host processor uses the slave device connected to the slave connector.

2. An apparatus according to Claim 1, the protocol providing for the generation of a connection signal on the host connector when the slave device is introduced into the system at the slave connector, the hub circuit being arranged to generate said connection signal when the alternative host processor stops using the slave device later than incorporation of the hub station into the system via the host connector.

3. An apparatus according to Claim 1, the protocol providing for the generation of a connection signal on the host connector when the slave device is incorporated into the system at the slave connector, the protocol providing for transmission of an identification code from the host connector or the local host processor to the slave device in response to introduction of the slave device into the system via the slave connector, the apparatus being arranged to compare a first identification code value transmitted by the local host to the slave connector with a second identification code value received subsequently from the host

connector, and to disregard the incorporation into the system at the host connector upon detection of equality of the first and second identification code value.

4. An apparatus according to claim 3, wherein the local host processor is arranged to transmit a third identification code value upon said detection of equality, the introduction to the system via the host connector being disregarded upon reception of a fourth identification code value equal to the third identification code value from the host connector.

5. An apparatus according to Claim 1, wherein the hub circuit generates a shut-down signal to the local host processor upon detection of the incorporation into the system via the host connector, the local host processor being arranged to respond to said shut-down signal by completing the use of the slave device, and to subsequently generate a signal to the hub circuit that the slave port is no longer in use.

6. An apparatus according to Claim 5, wherein said shut down signal is generated as a connection signal signaling connection of a further slave device to a virtual slave connector of the apparatus.

7. An apparatus according to Claim 1, the apparatus comprising flag storage, the local processor setting the flag storage to an in use state or to a not in use state depending on whether the local host processor uses the slave connector or not respectively, the hub circuit testing the state of the flag storage to determine said presence/absence signal.

8. A system comprising at least a first and second communication bus system that both contain a shared hub station, the communication bus systems containing a first and second host station respectively, for incorporating slave stations and controlling communication with the slave stations in the first and second communication bus system respectively, the shared hub station having a slave connector for connecting a slave station, the first and second communication bus system each operating according to a communication protocol wherein the hub station generates a presence signal for the slave connector upon incorporation of the hub station into the relevant system, the presence signal being dependent on whether the shared hub station detects a slave station connected to the slave connector, wherein the shared hub station is arranged to make a selectable assignment of the slave connector to the first or to the second communication bus system, the shared hub station

supplying the signals that it normally generates in response to the absence of a connection to the slave connector to the second host station if the shared hub station assigns the slave connector to the first communication bus system.

9. A system according to Claim 8, the shared hub station being arranged to switch the assignment to a newly assigned communication bus system of the first and second communication bus system, the shared hub station generating a connection signal corresponding to connection of the slave station to the slave connector when the shared hub station switches the assignment and supplying the connection signal to the host station of the newly assigned communication bus system.

10. A system according to Claim 1, the shared hub station being arranged to compare a first identification code value, transmitted via the slave connector upon introduction of a station into the first communication system via the slave connector, with a second identification code value received subsequently from a host connector for connecting the shared hub station to the second communication bus system, and to break off the incorporation into the first communication bus system in response to detection of equality of the first and second identification code value.

ABSTRACT:

A communication bus system contains a host station and a slave station. An apparatus is connected between the host and slave station. The communication bus system operates according to a communication protocol wherein the hub station generates a presence signal on the host connector upon incorporation of the hub station into the system via the host connector. The presence signal is dependent on whether the hub station detects a slave device connected to the slave connector. The apparatus comprises an alternative host port and a hub circuit. The hub circuit being arranged to pass communication between the alternative host processor and the slave device via the alternative host port and said slave connector. The hub circuit generate the presence signal simulating absence of a connection to the slave connector when the hub station is incorporated into the system at a time when the alternative host processor uses the slave device connected to the slave connector.

Fig.2

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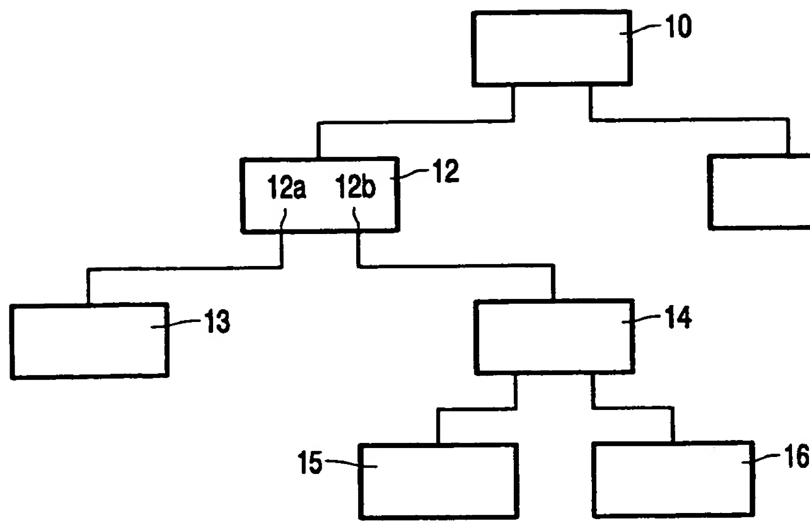

FIG. 1

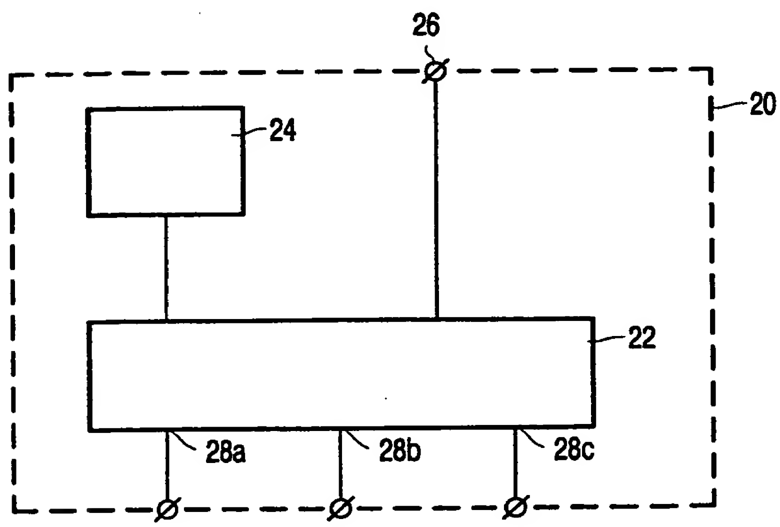

FIG. 2

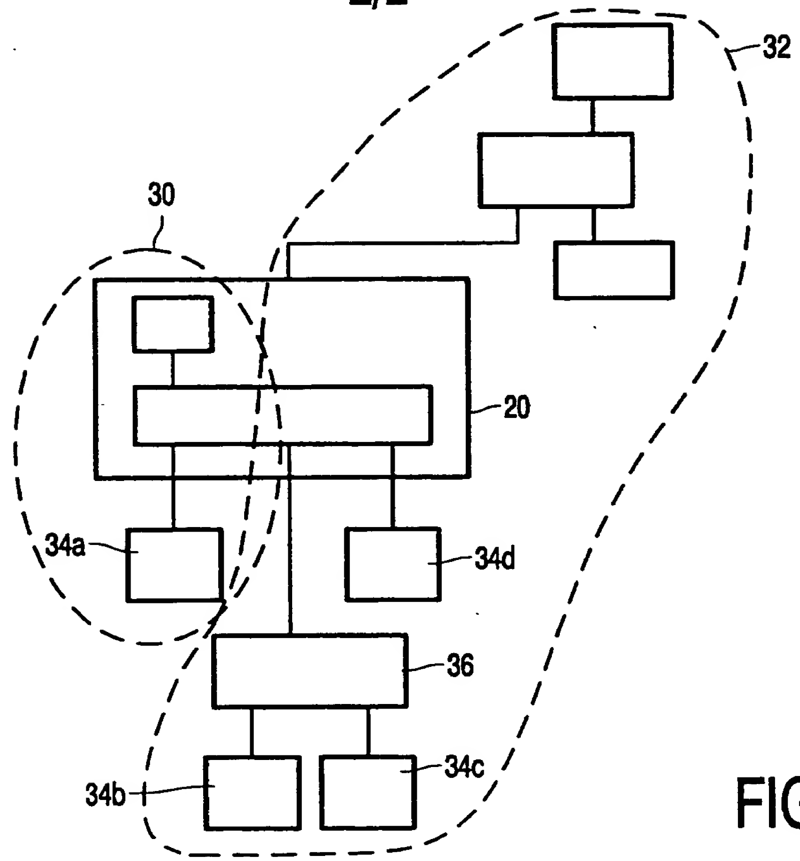

FIG. 3

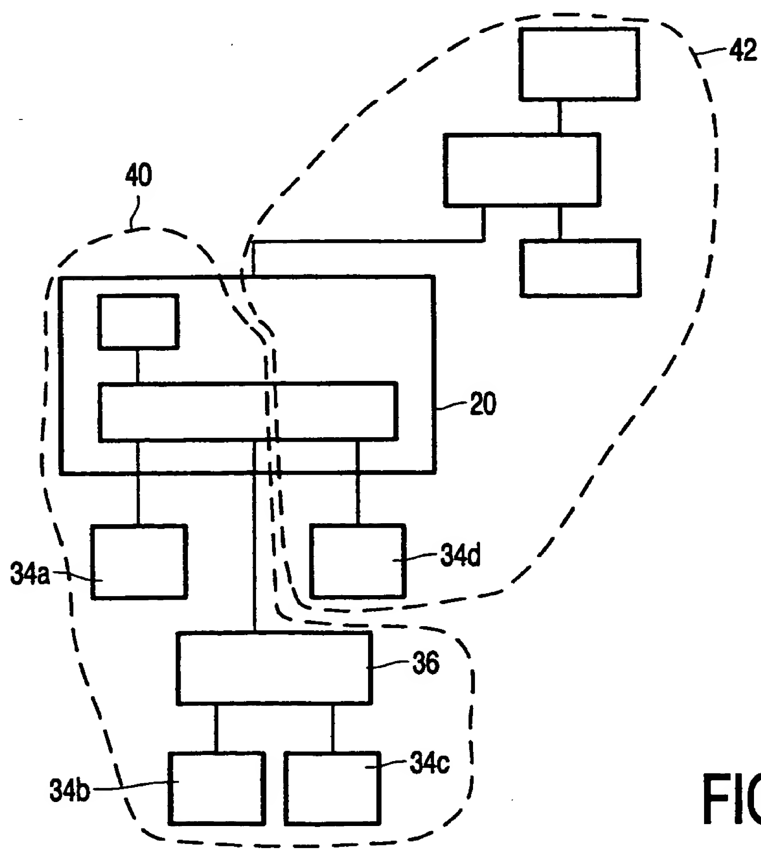

FIG. 4